COMPARATIVE ANALYSIS OF ENERGY EXPENDITURE AT DIFFERENT STAGES OF SLOW AND FAST YOGIC NOSTRIL BREATHING

SHORT SYNOPSIS

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Certificate

In order to partially fulfill the requirements for the Doctor of Philosophy in Exercise Physiology degree under the faculty of Exercise Physiology of Lakshmibai National Institute of Physical Education, Gwalior (M.P.) during the academic year 2021, I hereby declare that the brief summary, "**Comparative Analysis Of Energy Expenditure At Different Stages Of Slow And Fast Yogic Nostril Breathing**" as submitted.

It is a legitimate record of original work completed under Dr. Payel Das's guidance, and it hasn't been submitted in whole or in part for a degree or diploma to any other university or institution. Additionally, the evidence has been supplied and the brief overview is guaranteed to be free of plagiarism.

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ABSTRACT

More human therapies are now available than ever before thanks to the rapid advancements in science and technology. Its goals are insufficient and illusory. The public and professional community's interest in physical activity and health has significantly increased due to a number of factors, including the constraints of contemporary life, the limitations put on physical exercise, and other factors. Exercise that gives you more free time and raises your chances of surviving to be 100 years old. People seem to be "turning on" to the idea that getting more exercise enhances one's general health, happiness, and beauty. "Pranayama" is a Sanskrit term that meaning "extension of the life force" or "extension of the praṇa, or breath." The phrase comes from two Sanskrit words: "prana," which means life force or vital energy, namely the breath, and "ayama," which means to expand or draw out.

To the best of our knowledge, no research has looked at how much oxygen is consumed, how much carbon dioxide is produced, or how much energy is expended when practicing slow and rapid Yogic nostril breathing, which is typically referred to as pranayama and shatkarma. In order to investigate the effects of slow and fast yoga nostril breathing on energy expenditure, carbon dioxide generation, and oxygen intake, among other variables, in healthy volunteers before, during, and after these two practices, the current study was conducted.

Keywords: Pranayama, Volume of Carbon Dioxide production (VCO2), Volume of Oxygen Consumption (VO2), MVV (Minute Volume Ventilation), FVC (Forced Vital Capacity) ,RR (Rate of respiration), EE (Estimated energy expenditure), SPO2 (Saturation of peripheral oxygen), Respiratory Equivalent Ratio, Slow pace, Fast pace, Kapalbhati, Bhastrika pranayama

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INTRODUCTION

Introduction of Yoga

"Yoga is not an ancient myth buried in oblivion. It is the most valuable inheritance of the present. It is the essential need of today and the Culture of tomorrow. "
- Swami SatyanandaSaraswati (S. S. Saraswati. (2002)

"Yoga is integration and harmony between thought, feeling and deed, or integration between head, heart and hand". - Swami Sivananda Saraswati (S. S. Saraswati. (2002)

In this modern era, Yoga is being popularizing more throughout the world due to its significant effect on overall health of the person. Yoga should be including in our daily life as it helps to be physical, mental, social as well as spiritual development.

The word yoga is derived from the Sanskrit root word 'yuj' which means to join, attach or unite. In other words, in spiritual term it means union of individual consciousness to the universal consciousness.

On an applied perspective, yoga is the unification of body, mind and soul. It also helps to balance our pranas thus helps in proper flow of pranas throughout the body. It can be achieved through the practice of several yogic practices like asana, pranayama, mudra, bandha,shatkarma (internal cleaning process), and meditation. Yoga helps to maintain the proper functioning of all systems (cardiovascular system, respiratory system, excretory system, endocrine system, muscular system, nervous system, digestive system etc.) of the body. (S. S. Saraswati. (2002)

Different streams of yoga (hatha yoga, mantra yoga, ashtanga yoga, karma yoga, bhakti yoga, raj yoga etc.) have the same aim as to achieve the state of self-realization.

PRANAYAMA

Pranayama is a Sanskrit word meaning "extension of the praṇa or breath" or, "extension of the life force". The word is composed of two Sanskrit words, Prana, life force, or vital energy, particularly, the breath, and "ayama", to extend or draw out.
Pranayama means a pause in the movement of breath. In the Sutras the word Prana occurs by itself only once and the wording of Sutras is so clear that by no stretch of thoughts can the word Prana there be taken to refer to anything aspect breath. In addition to this the word Prana occurs twice in the sutras every time being compounded with the word Ayama. Here again the wording of the original author, Patanjali is very clear. He positively refers to respiratory moments. The most imperative commentators Patanjali's Sutras have invariable explained Prana to mean breath. (Hartranft, 2003)

In the language of the later yogic literature Pranayama is called Kumbhaka. It is interesting to note here that Patanjali does not use the terms Recaka (Exhalation), Kumbhaka (pause) and puraka (inhalation) anywhere in his sutras, although he does pass on to these actions. His oldest commentator Vyasa, who lived in the first century, A.D. also, does not use the terms Rechaka, Kumbhaka and Puraka. This circumstance clearly shows that this nomenclature was introduced at a later date.

Tracing the history of the development, of not only these terms but many others used in the Yoga Sastra, would be a fruitful research problem for a student of yogic literature.

The duration is Pranayama should be judged mentally. Both the physical culturists and the spiritual culturists should practice Pranayama with maximum concentration. The mind should very closely follow the movement of breath. In numbering the Matras the concentration of the breath is troubled. Again the spirit culturist, as he advances, is required to concentrate on different points either inside the body or outside it. In this work the numbering of the Matras causes a little distraction. Those that can manage the numbering business without allowing their attention being affected, may take it if they so choose.

KAPALBHATI

The process of Kapalbhati is related to the breathing process, however it is not a type of Pranayama. But, certain Sadhakas think in this manner and study Kapalbhati under the impression that they are studying a type of Pranayama. However, process of cleaning the wind pipe is one of the shuddhikriyas.

"According to the Gherand Samhita there are six groups of yogic cleansing techniques. They are called the Shatkarmas and are as follows: dhauti, basti, neti, nauli, trataka and bhalbhati. Included in some of these groups are a number of different techniques. In the Hatha Yoga Pradipika the Shatkarmas are the same as listed here, but instead of bhalbhati the sixth Shatkarma is given as Kapalbhati. Often these are regarded as the same practice with different names but actually they are completely different. These two classical texts have chosen to adopt two totally different practices for the last Shatkarma.

BACKGROUND

In yoga, considerable emphasis is placed on the breath. Yoga breathing techniques are ultimately intended to enhance a practitioner's ability to achieve a calm mental state at will. However, since these practices regulate and modify different aspects of the breath (the rate, depth, or adding a period of breath-holding), they have a direct effect on physiological functions such as oxygen consumption.

An early study examined oxygen consumption (VO_2) during 3 yoga breathing practices in a single subject (male, aged 32 years). The VO_2 increased significantly by (i) 11.9% during high-frequency yoga breathing (*kapalabhati*, at 80 breaths per minute for 30 minutes), (ii) 18.9% during slow deep breathing (*bhastrika* practiced for 24 minutes), and (iii) 18.0% during breathing with retention after inhalation (*ujjayi*, practiced for 22 minutes). All comparisons were made with the previous values. The results of this early study were supported by later research.

High-frequency yoga breathing was found to increase VO_2 compared to the preceding values in at least 2 other studies. Three males (average age 35.7±11.7 years) who breathed at 232 breaths per minute for 30 minutes showed a 203% increase in VO_2. A slower rate of high-frequency yoga breathing showed a similar trend, but with a smaller magnitude of change; 47 males (average age 23.2±4.1 years) breathed at 60 breaths per minute for 15 minutes, and VO_2 increased by 40%.

Similarly, 3 studies found that yoga breathing with a period of breath retention also increased VO_2 compared to the preceding values. The findings were as follows: (i) in 10 males (ages 28–50 years), after 15 minutes of practice, there was a 52% increase in VO_2, (ii) in a single subject (male, 26 years of age) with a slow breath rate of 1 breath per minute for 60 minutes, there was an increase of 11%, and (iii) in 9 experienced yoga practitioners (5 males, average age 44.0±11.6), yoga breathing with retention practiced for 30 minutes after inhalation increased VO_2 by 20%.

To the best of our knowledge, there has been no study examining oxygen consumption, carbondioxide production and energy expenditure related to the practice of slow and fast Yogic nostril breathing which have been traditionally described as shatkarma practice and pranayama. Hence, the present study aimed to assess the effect of *slow and fast yogic nostril breathing*on energy expenditure, carbondioxide production and oxygen consumption, among other variables, in healthy participants compared to pre, during and post practices of these two practices.

LITERATURE

(Telles et al., 2020) conducted a study on body temperature and energy expenditure during and after yoga breathing practices traditionally described as cooling. Seventeen healthy male volunteers with ages between 19 to 25 years (average age 20.7±1.8 years) were assessed in 4 sessions, viz. *sheetali pranayama, sitkari pranayama*, breath awareness and quiet lying, on 4 separate days, in random sequence. The axillary surface body temperature (TRUSCOPE II, Schiller, China) and metabolic variables (Quark CPET, COSMED, Italy) were recorded in 3 periods: before (5 minutes), during (18 minutes), and after (5 minutes), in each of the 4 sessions. The heat index was calculated in the before and after periods, based on recordings of ambient temperature and humidity. Data were analyzed using SPSS (Version 24.0). Oxygen consumption increased by 9.0% during *sheetali* ($p<0.05$) and by 7.6% during *sitkari* ($p<0.01$) while it decreased significantly during ($p<0.05$) and after ($p<0.01$) quiet lying down compared to respective pre-exercise states.

(Miles, 1964) conducted a study on Oxygen consumption during three yoga-type breathing patterns. The study was made by means of basal metabolism technique, employing the Krogh recording spirometer. All three of the yoga breathing patterns examined, when individually continued for 20 min or more and compared with previous relaxed quiet breathing, were found to demand an increased oxygen consumption of a mere 12–35% above basal need. The relaxed breathing that immediately followed a yoga pattern gave little or no indication that the subject had been exerting himself. There is some indication that such respiratory training may have elements in common with adaptation to high altitude and may serve to fortify an individual against the early onset of hypoxia in emergencies concerned with oxygen supply. Respiration training exercises; BMR during trained respiratory behavior; respiratory measurements during yogic breathing; thoracic and abdominal breathing; breathing patterns versus breathing rates; yogic breathing patterns; voluntary pause after inspiration; domestication of respiration; discipline for the diaphragm; higher education for the respiratory center

(Frostell et al., 1983) conducted a study on Effects of high-frequency breathing on pulmonary ventilation and gas exchange. The effects of spontaneous high-frequency breathing (HFB) on lung function were evaluated in three subjects highly trained in the practice of yoga. Transpulmonary pressure was measured by an esophageal balloon catheter and gas flow by pneumotachography. The abdominal and rib cage contributions to tidal breathing were measured separately by respiratory inductive plethysmography. Gas exchange was studied by the conventional technique and by multiple inert gas elimination. During HFB, respiratory rate increased to 232 cycles/min with a tidal volume of 0.35 liter. This resulted in a more than 10-fold increase in expired minute ventilation to approximately 90 1/min. The transpulmonary pressure varied by 20 cmH2O, with the calculated elastic, resistive, and accelerative components varying by 2, 20, and 8 cmH2O, respectively. Respiratory work increased more than 200-fold in comparison with resting ventilation. A phase shift between thoracic and abdominal breathing was observed and was interpreted as a volume displacement of approximately 30 1/min between the two parts of the respiratory system. Arterial oxygen and carbon dioxide tension remained normal. Bohr dead space increased, while acetone dead space remained unaltered.

A bimodal distribution of ventilation-perfusion ratios (VA/Q) was observed, with one mode in normal and another in "high" VA/Q regions.

(Telles et al., 2015) conducted a study on Metabolic and Ventilatory Changes During and After High-Frequency Yoga Breathing. Healthy male volunteers (n=47, group mean age ± S.D., 23.2 ± 4.1 years) were recruited as an experimental group and another twenty volunteers were recruited as a control group. The experimental group practiced either HFYB (Breath rate 1.0 Hz) or breath awareness (BAW) on two separate days. The sequence was reversed for alternate participants. The control group was assessed under similar conditions while sitting at ease. The breath rate (RR), tidal volume (VT), ventilation (VE), VO2, VCO2, arterial PCO2 and energy expenditure (EE Kcal/day) were assessed for 35 minutes using an open circuit oxygen consumption analyzer. The assessment period was divided into before, during and after conditions. Repeated measures analyses of variance (ANOVA) were used to compare data recorded during and after the two practices with data recorded before. Before-After comparisons in the control group were with paired t-tests. RESULTS The most relevant significant changes were increases in VE, VO2, VCO2 and EE during HFYB, while the same variables decreased during the control period. However after HFYB there was no change in VO2 or EE, although VE decreased as it did after the control period. CONCLUSIONS HFYB induces a hypermetabolic state for the duration of the practice which returns to baseline after HFYB suggesting a possible application for HFYB in hypometabolic states.

(Telles et at., 1991) conducted a study on Oxygen consumption during pranayamic type of very slow-rate breathing. To determine whether the yogic Ujjayi pranayamic type of breathing that involves sensory awareness and consciously controlled, extremely slow-rate breathing including at least a period of end-inspiration breath holding in each respiratory cycle would alter oxygen consumption or not, ten males with long standing experience in pranayama, and volunteering to participate in the laboratory study were assessed. These subjects aged 28-59 years, had normal health appropriate to their age. Since Kumbhak (timed breath holding) is considered as an important phase of the respiratory cycle in the pranayama, they were categorised into two groups of five each, one group practising the short Kumbhak varieties of pranayama, and the other the long Kumbhak varieties of pranayama. The duration of Kumbhak phase was on an average 22.2 per cent of the respiratory cycle in the short Kumbhak group and 50.4 per cent in the long Kumbhak group. The oxygen consumption was measured in test sessions using the closed circuit method of breathing oxygen through the Benedict-Roth spirometer. Each subject was tested in several repeat sessions. Values of oxygen consumption of the period of pranayamic breathing, and of post- pranayamic breathing period, were compared to control value of oxygen consumption of the prepranayamic breathing period of each test session. The results revealed that the short Kumbhak pranayamic breathing caused a statistically significant increase (52%) in the oxygen consumption (and metabolic rate) compared to the pre-pranayamic base-line period of breathing. In contrast to the above, the long Kumbhak pranayamic breathing caused a statistically significant lowering (19%) of the oxygen consumption (and metabolic rate). The values returned to near normal in the post-pranayamic periods. The data provide a basis to indicate that different types of pranayamic breathing may lead to different types of alterations in the oxygen consumption and metabolic rate.

(Miyamura et al., 2002) conducted a study on Is Man Able to Breathe Once a Minute for an Hour?: The Effect of Yoga Respiration on Blood Gases. The ventilatory response to hypercapnia and arterial blood gases during ujjai respiration of once per minute for an hour were determined in a professional hatha yogi. The results suggest that lower chemosensitivity to hypercapnia in yoga practitioners may be due to an adaptation to low arterial pH and high $P\mathrm{aCO_2}$ for long periods.

(Danucalov et al., 2008) conductes a study on Cardiorespiratory and Metabolic Changes during Yoga Sessions: The Effects of Respiratory Exercises and Meditation Practices. The novelty of this study was to investigate the changes in cardiorespiratory and metabolic intensity brought about by the practice of pranayamas (breathing exercises of yoga) and meditation during the same hatha-yoga session. The technique applied was the one advocated by the hatha-yoga system. Nine yoga instructors-five females

and four males, mean age of 44+/-11, 6, were subjected to analysis of the gases expired during three distinct periods of 30 min: rest, respiratory exercises and meditative practice. A metabolic open circuit computerized system was applied (VO2000, MedGraphics-USA). The oxygen uptake (VO(2)) and the carbon dioxide output (VCO(2)) were statistically different (P <or= 0.05) during meditation and pranayama practices when compared with rest. The heart rate also suffered relevant reductions when results at rest were compared with those during meditation. A smaller proportion of lipids was metabolized during meditation practice compared with rest. The results suggest that the meditation used in this study reduces the metabolic rate whereas the specific pranayama technique in this study increases it when compared with the rest state.

Sinha et aL J (2004) conducted a study on energy cost and cardio respiratory changes during the practice of Suryanamaskar (SN). The present study was undertaken to observe critically the energy cost and different cardio respiratory changes during the practice of SN. Twenty one male volunteers from the Indian Army practiced selected Yogic exercises for six days in a week for three months duration. The Yogic practice schedule consisted of Hatha Yogic Asana (28 min), Pranayama (10.5 min) and Meditation (5 min). After three months of training at the beginning of the fourth month subjects performed entire Yogic practice schedule in the laboratory as they practiced during their training session and experiments were carried out. Their pulmonary ventilation, carbon dioxide output, Oxygen consumption, HR and other cardio respiratory parameters were measured during the actual practice of SN. Oxygen consumption was highest in the eighth posture (1.22", 0.0731 min-I) and lowest in the first posture (0.35 '" 0.02 I min-I). Total energy cost throughout the practice of SN was 13.91 kcal and at an average of 3.79 kcal/min. During its practice highest HR was 101 '" 13.5 b.p.m. As an aerobic exercise SN seemed to be ideal as it involves both static stretching and slow dynamic component of exercise with optimal stress on the cardio respiratory system.

DESCRIPTION OF BROAD AREAS

Energy- A fundamental entity of nature that is transferred between parts of a system in the production of physical change within the system and usually regarded as the capacity for doing work

Expenditure- The act or process of expending

Minute Volume Ventilation-Minute volume ventilation is defined as the amount of air breathed per minute. It is expressed in Lpm.

VO2 max. - VO_2 max refers to how much oxygen your body can absorb and use during exercise.It is expressed in L/Min.

VCO2 (Volume of carbon dioxide output) - Refers to the amount of carbon dioxide exhaled from the body per unit time. It is expressed in ml/min. A normal value at rest is around 200 ml/min.

FVC (Forced Vital Capacity) - The breathing capacity of the lungs expressed as the number of cubic inches or cubic centimeters of air that can be forcibly exhaled after a full inspiration. Its measured in litre.

RR (Rate of respiration) - A person's respiratory rate is the number of breaths you take per minute. The normal respiration rate for an adult at rest is 12 to 20 breaths per minute.

EE (Estimated energy expenditure) - Energy expenditure can be estimated by measuring macronutrient or oxygen consumption, or heat production or carbon dioxide production.

OBJECTIVES OF THE STUDY

The objectives of the study are:

- To analyze and compare the energy expenditure between slow and fast nostril breathing.
- To compare the energy expenditure between the slow and fast pranayama at different stages pre, during and post.
- To compare the energy expenditure between the kapalbhati and bhastrika pranayama at different stages pre, during and post.
- To analyze that at which stage the energy expenditure is higher in Kapalbhati
- To analyze that at which stage the energy expenditure is higher in Bhastrika pranayama

RESERCH METHODOLOGY

In this chapter, the selection of subjects, selection of variables, criterion measures, administration of test, collection of data and statistical technique for analysis of data has been described.

SELECTION OF SUBJECTS

To attain the purpose of the study, 45 females who are yogic practitioner of Gwalior city will be selected randomly as subjects of the study. The age of the subjects will be ranged from 25-30 years.

SELECTION OF VARIABLES

Some of the physiological variables will be selected for the study, as follow:

i) VO2 (Volume of oxygen)
ii) VCO2 (Volume of carbon dioxide output)
iii) MVV (Minute Volume Ventilation)
iv) FVC (Forced Vital Capacity)
v) RR (Rate of respiration)
vi) EE (Estimated energy expenditure)
vii) SPO2 (Saturation of peripheral oxygen)
viii) Respiratory equivalent ration (RER)

CRITERION MEASURES

Metabolic Analyzer, Pulse Oximeter, Dry Spirometer will be used to measure the following physiological variables:

i) VO2 (Volume of oxygen consumption)
ii) VCO2 (Volume of carbon dioxide eliminated)
iii) MVV (Minute Volume Ventilation)
iv) FVC (Forced Vital Capacity)

v) RR (Rate of respiration)
vi) EE (Estimated energy expenditure)
vii) SPO2 will be measured by pulse oximeter.
viii) Respiratory equivalent ration (RER)

ADMINISTRATION OF TEST

- The data will be taken individually by using metabolic analyzer but in empty stomach.
- Demonstration of Kapalbhati and Bhastrika pranayama will be given.
- Each nostril breathing yogic practices will be given for total 6 minutes.
- Fast pace nostril breathing will be performed at 0-120 breath/ min and slow paced will be performed at 10-15 breath/minute.

COLLECTION OF DATA

- Each subject will ask to sit quietly in the laboratory for 10 minutes prior to each of the 2 sessions so that they could adapt the laboratory environment or conditions.
- Throughout the assessment the subject, will monitored by the research and the subjects will be informed about this observation, which will allow researcher to detect the subjects movements in relation to sleep or sign of discomfort.

STATISTICAL TECHNIQUE

In order to compare the different stages of Kapalbhati and Bhastrika pranayama at different paces, mixed design Repeated MANOVA (RM-MANOVA) will be used. The level of significance will be set at .05

EXPECTED OUTCOME OF THE STUDY

The study may contribute in the following ways:-

- The results of this study will be helpful to prepare a healthy yoga module for sports persons
- The study will be helpful for medical curative and rehabilitation programme for peoples suffering from respiratory and cardiovascular disorders in early age.
- The study will provide the scientific base for the ancient Indian culture and discipline of yoga which our ancestors advised for general well being and healthy living
- The result of the study may highlight that, in which yogic practice the energy expenditure is higher.
- The result of the study also highlights that which yogic practice is effective for which variable.
- The result of the study may highlight effect of different stages of kapalbhati and bhastrika pranayama with respect to time.

- The findings of the study will add new knowledge in the field of yoga and physical education

REFERENCES

1. Muktibodhananda S. *Hatha Yoga Pradipika: Light on Hatha Yoga.* 2nd ed. Bihar (India): Yoga Publication Trust; 2002.
2. Telles, S., Gandharva, K., Sharma, S. K., Gupta, R. K., & Balkrishna, A. (2020). Body Temperature and Energy Expenditure During and After Yoga Breathing Practices Traditionally Described as Cooling. *Medical Science Monitor Basic Research, 26*. https://doi.org/10.12659/MSMBR.920107
3. Miles WR. Oxygen consumption during 3 yoga-type breathing patterns. *J Appl Physiol*. 1964;19:75–82.
4. Frostell C, Pande JN, Hedenstierna G. Effects of high-frequency breathing on pulmonary ventilation and gas exchange. *J Appl Physiol Respir Environ Exerc Physiol*. 1983;55:1854–61.
5. Hartranft, C., (2003) The Yoga-Sutra of Patanjali: a new translation with commentary, Shambhala Publications.
6. Hewitt, J. (2012) The Complete Yoga Book: The Yoga of Breathing, Posture and Meditation, Random House.
7. Telles S, Singh N, Balkrishna A. Metabolic and ventilatory changes during and after high-frequency yoga breathing. *Med Sci Monit Basic Res*. 2015;21:161–71.
8. Telles S, Singh N, Balkrishna A. Heart rate variability changes during high frequency yoga breathing and breath awareness. *Biopsychosoc Med*. 2011;5:4.
9. Telles S, Verma S, Sharma SK, et al. Alternate-Nostril yoga breathing reduced blood pressure while increasing performance in a vigilance test. *Med Sci Monit Basic Res*. 2017;23:392–98.
10. Telles S, Desiraju T. Oxygen consumption during pranayamic type of very slow-rate breathing. *Indian J Med Res*. 1991;94:357–63.
11. Miyamura M, Nishimura K, Ishida K, et al. Is man able to breathe once a minute for an hour?: The effect of yoga respiration on blood gases. *Jpn J Physiol*. 2002;52:313–16.
12. B. Sinha., U.S. Ray., A. Pathak., & W. Selvamurthy. (2004). Energy Cost and Cardio respiratory Changes During The Practice Of Suryanamaskar. Indian J Physiol Pharmacol, 48(2), 184-190.
13. *Vital Signs*. (n.d.). Cleveland Clinic. Retrieved May 24, 2022, from https://my.clevelandclinic.org/health/articles/10881-vital-signs
14. Hills, A. P., Mokhtar, N., & Byrne, N. M. (2014). Assessment of Physical Activity and Energy Expenditure: An Overview of Objective Measures. *Frontiers in Nutrition*, *1*, 5. https://doi.org/10.3389/fnut.2014.00005
15. *Energy Definition & Meaning—Merriam-Webster*. (n.d.). Retrieved May 24, 2022, from https://www.merriam-webster.com/dictionary/energy
16. *Respiratory Minute Volume—An overview | ScienceDirect Topics*. (n.d.). Retrieved May 24, 2022, from https://www.sciencedirect.com/topics/medicine-and-dentistry/respiratory-minute-volume
17. Minute ventilation. (2024). In *Wikipedia*.

    https://en.wikipedia.org/w/index.php?title=Minute_ventilation&oldid=1245211341
18. *Forced Vital Capacity—An overview | ScienceDirect Topics*. (n.d.). Retrieved February 27, 2025, from https://www.sciencedirect.com/topics/nursing-and-health-professions/forced-vital-capacity
19. Chourpiliadis, C., & Bhardwaj, A. (2025). Physiology, Respiratory Rate. In *StatPearls*. StatPearls Publishing. http://www.ncbi.nlm.nih.gov/books/NBK537306/
20. Hegg, J. (2016, September 28). *Understanding SpO2 and Normal Oxygen Levels*. https://www.homecaremag.com/understanding-spo2-and-normal-oxygen-levels
21. Ramos-Jiménez, A., Hernández-Torres, R. P., Torres-Durán, P. V., Romero-Gonzalez, J., Mascher, D., Posadas-Romero, C., & Juárez-Oropeza, M. A. (2008). The Respiratory Exchange Ratio is Associated with Fitness Indicators Both in Trained and Untrained Men: A Possible Application for People with

Reduced Exercise Tolerance. *Clinical Medicine. Circulatory, Respiratory and Pulmonary Medicine*, *2*, 1–9.

22. *KapalBhati | Benefits | How to do | Steps | Kapal Bhati—The Art of Living*. (2023, July 5). https://www.artofliving.org/in-en/yoga/pranayama/kapalbhati
23.

24. *VO_2 Max: Definition, How It's Measured, How to Improve*. (n.d.). Retrieved May 24, 2022, from https://www.healthline.com/health/vo2-max